

# What sources do individuals use to validate arguments in scientific discourses today? An exploratory study of YouTube comments on vaccination

Exploratory  
study of  
YouTube  
comments

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## Abstract

**Purpose** – This study aims to explore scientific discourses on vaccination in YouTube comments using the Connectivism theory as a foundational guide in the inquiry of understanding knowledge seeking and sharing. The authors sought to understand how individuals share and seek information by using external sources through URL links to validate their arguments.

**Design/methodology/approach** – Using content analysis, the authors extracted and analysed 584 random comments with URL links from eight YouTube videos scientifically addressing the purpose of vaccines. The comments were coded by stance (pro, anti, and neutral) and the type of resource to observe how their links were used.

**Findings** – The results showed that URL links were composed of quotes, questions, and opinions. Many sources came from research papers, conspiracy websites, or other videos. Some of the comments did not accurately reflect the information from research papers and showed little scientific reasoning. This suggests the need for critical evaluation among individuals when finding information online.

**Research limitations/implications** – The findings can be expanded to explore different types of information literacy practices in the comment section of social media for both informal and formal environments.

**Practical implications** – YouTube is useful in fostering scientific discourse and information-seeking/sharing practices among individuals. However, considering the inaccuracy of content deliverance, educators and individuals will need to consider how to teach/conduct information literacy skills when implementing social media for educational purposes.

**Originality/value** – Only a few studies have conducted research on comments using URL links, the originality of sources and how the sources were used in argumentation.

**Keywords** Vaccine discourse, YouTube comments, Social media, Information literacy, Connectivism, Misinformation, Information sources

**Paper type** Research paper



## Introduction

YouTube has been noticed by educators and learners as an effective informal learning tool for its ability to share informative content through visual and auditory methods that are engaging for learners (Lee *et al.*, 2017). The social media platform allows users to upload videos publicly to convey opinions, information, or entertainment on all topics. The uploaded contents are then sustained over lengthy periods of time, and individuals can access the contents whenever they wish. In other words, YouTube functions as a large library archive or node which fosters a connectivist approach to individual learning, where it is used to engage in searching, retrieving, and evaluating information and allows interaction with other users using the comments section (Siemens, 2005). With these characteristics, the popularity of the platform has been rising rapidly since 2019, especially among the younger generation relying on it for information consumption and entertainment (Auxier and Anderson, 2022; Chen, 2020). YouTube videos are also being used for learning in diverse ways, such as practising digital literacy (Meyers, 2012), studying language and culture (Benson, 2015), and replicating tutorials on certain topics (Lange, 2018). The informative characteristic of the platform helps individuals bridge informal and formal learning and helps them actively engage and connect with other learners (Haugsbakken and Langseth, 2014). In such an environment where individuals indulge in self-directed actions to seek, discover, and deliver knowledge for themselves or others, it is not surprising to notice arguments, ideas and motivations clash among others online, especially in the light of scientific information (Lange, 2018). Taking this into account, examining scientific discourse has been an area of interest for numerous studies since they can shape the public's attitudes towards science, elicit their motivations, and foster scientific understanding (Berland and Reiser, 2011; Nelon *et al.*, 2021). Discourse or argumentation, described as engaging in the sharing of thoughts, ideas, and opinions among other people, can occur in online spaces synchronously or asynchronously (van Aalst, 2009). YouTube is an example of a social media platform where such interactions take place through videos and comments, from which content creators can receive feedback, ideas, or suggestions (Lange, 2018). In addition, users of YouTube can engage in discourse based on the content of the video (Koehler and Vilarinho-Pereira, 2021; Lange, 2014). YouTube, especially is known to foster scientific discourse as it allows content creators to provide different forms of creativity and entertainment in their content, which then helps with knowledge sharing and provoke engagement on a more friendly level to its audiences (Boy *et al.*, 2020).

In this paper, we focus on scientific discourse on vaccination. The topic of vaccination has a long history of controversy, which has evoked strong opposing viewpoints on whether it should be mandated or not, provoking active discourse among online users to bring different online sources to prove their arguments to the opposing sides. One of those controversies stem from the famous research paper published by Andrew Wakefield, who presented misinformation about the relationship between vaccinations and autism that caused people to doubt the reliability of vaccines (Kolodziejski, 2014). Due to its controversy, YouTube videos addressing the vaccination topic are constantly being created, and they are popular destinations for viewers across the globe (Donzelli *et al.*, 2018). There are various vaccine-related videos on the platform, from news reports, educational videos, influencers, satire, TV show clips and to podcasts that either explain, agree or disagree with the biological products. The debate surrounding vaccines has also intensified during the COVID-19 pandemic, with the rapid production and mandates of the COVID-19 vaccines raising concerns among the public and spreading misinformation (Nguyen and Catalan-Matamoros, 2022). The dissemination of fake news on social media platforms has been an

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issue that was inflated during this time prompting vaccine hesitancy, which questions the need for some sort of intervention in information literacy practices (Prada *et al.*, 2023).

In vaccine-related discourses, individuals use various strategies to support their stances. The most common strategy involves providing narratives with emotional appeals, invoking fear, guilt, or shame (Scannell *et al.*, 2021). However, recent studies have observed individuals providing external evidence, such as research papers or clinical reports, to support their arguments (Metwally, 2021; Striewski *et al.*, 2022; Thieu *et al.*, 2022). In this paper, we define our individual commentators as “YouTube users”, the individuals who view or react to YouTube videos and seek to examine how they use external evidence in vaccine discourse comments with URL links (Khan, 2017; Lee *et al.*, 2017). URL links are widely used in online comments as a method to reference external evidence, enabling users to access and share information from other domains by acting as a bridge between webpages (Sams and Park, 2014). Many studies have looked at how URL links contribute to knowledge sharing and construction in online spaces (Striewski *et al.*, 2022; Vaughan, 2016).

In this paper, we explore how YouTube users use URL links in vaccine discourse. Specifically, we aim to answer to questions:

- Q1. Which type of information sources did YouTube users rely on when providing evidence for their scientific arguments?
- Q2. How are users sharing and using URL links to support their claims and arguments in their YouTube comments?

To address these questions, we analysed 584 comments from YouTube videos on vaccination. Firstly, we categorized and counted the types of information sources based on the stances expressed in the comments. Following this, we present qualitative observations on how users share and use these sources.

## Literature review

In this section, we provide an overview of literature related to YouTube and scientific discourse. We introduce how YouTube has become beneficial for informal learning environments and how its comments section helps enhance learning in the platform. Then, we focus our topic on vaccines and examine how previous studies have observed them in the context of commenting in different social media platforms. Finally, we introduce how connectivism and information literacy are relevant to the topic of YouTube, learning, and scientific discourse.

### *YouTube as an informal learning platform*

Informal learning environments allow individuals to practice self-paced learning without the pressures of assessments and authority positions (Lange, 2018). Social media is considered to be one of the informal learning environments that allows an individual to connect with other users online to share and construct information for different learning purposes (Ahmed *et al.*, 2019). YouTube is an example. The video-based platform has become one of the main sources of conversations and is easy to access outside of classrooms through mobile devices (Khan, 2017; Maziriri *et al.*, 2020). Through YouTube, people share science-related videos in different formats (e.g. animation, storytelling, etc.), which makes it more relatable to a general audience (Boy *et al.*, 2020). Although the platform was not originally intended as a learning platform, people have used it to seek information (Zhou *et al.*, 2020). Users also interact with video creators and other users via the comments feature provided for each video (Lee *et al.*, 2017). YouTube is different from other discourse-based social media platforms such as Reddit or Quora, which mainly consists of text-based Q&A

sessions or threads. Since YouTube is video-based, its popularity as a learning tool has grown in terms of information comprehension and engagement (Moghavvemi *et al.*, 2018). Many users seek these types of videos to gain knowledge and seek information (Zhou *et al.*, 2020). Using credibility based on video rankings, number of views, or number of subscribers, users are able to determine contents of interest to ask/answer questions and share opinions freely through the comments section (Dubovi and Tabak, 2020).

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#### *Learning implications of commenting and scientific discourse on social media*

Commenting on social media platforms allows users to become more immersed and engaged in learning (Chen, 2020). In their research, Swinnerton *et al.* (2017) illustrate how comments can be used as an effective learning tool for students who take massive open online course. Commenting has also influenced individuals who engage in self-directed learning (Lee *et al.*, 2017). YouTube users who are motivated to seek information are likely to refer to the comments for more information in addition to the videos they watch (Khan, 2017). Users can use the comment section to find answers or information for educational or personal inquiries after watching the videos (Lange, 2018). The multimodal environment of providing audio, visual, and commenting features helps foster engagement and interest in the topic being discussed (Haugsbakken and Langseth, 2014). In their study, Lee *et al.* (2017) mention how commenting helped learners feel a sense of community through the positive atmosphere of “affective sharing, gratitude, enjoyment” between each other and the video creator (p. 621).

Secondly, the commenting feature allows an individual to connect openly with other learners across the globe without time or locational constraints (Hamid *et al.*, 2015; Lee *et al.*, 2017). They can interact with diverse levels of experts that contribute to knowledge sharing (Lange, 2018). This enables individuals to better understand and evaluate the opinions of others. Individuals can learn social language, current trends, and self-expression through how others respond to certain situations and how they engage with others (Chen, 2020). Users can also actively seek clarification, evaluate various topics, and collaborate in knowledge sharing by engaging with both expert and non-expert learners (Asselin *et al.*, 2011; Eid and Al-Jabri, 2016; Dubovi and Tabak, 2020; Gierth and Bromme, 2020; Hamid *et al.*, 2015).

Thirdly, the commenting feature in social media platforms is known to prompt knowledge exchange through file sharing, discussions, and chatting, which help individuals to learn (Eid and Al-Jabri, 2016). In their study of examining comments in science-based YouTube videos, Dubovi and Tabak (2020) discovered that the most active users were able to gain elevated levels of knowledge co-construction, and their motivation to resolve disputes was heightened in this process. Meyers (2012) also found that individuals used comments to gain comprehension about certain subject matters and to build knowledge in specific areas.

Based on these features of YouTube promoting self-learning, interaction, and knowledge sharing with others, it is natural to notice how ideas or opinions can collide in the process of sharing and seeking information (Lange, 2018). This is especially evident in scientific discourses, where arguments are formed to convince or persuade others of certain situations (Berland and Reiser, 2011). To make their arguments more convincing, individuals use diverse sources or tactics to enhance their stance and appeal to others (Scannell *et al.*, 2021). On YouTube, many users gain connections with others and engage in discussions that begin from the viewed video through comments (Khan, 2017).

#### *Knowledge sharing with URL links and YouTube*

The methods of how scientific discourse occurs in online spaces can be examined through knowledge sharing. Knowledge sharing is explained as the actions individuals take to share

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information, skills, or expertise with each other (Bukowitz and Williams, 1999, as cited in Eid and Al-Jabri, 2016). According to van Aalst (2009), knowledge sharing focuses on the dissemination of existing information. It is different from knowledge construction and knowledge creation as they build on existing knowledge and generate new understandings. While the three are critical in knowledge forum, each differs in the level of learning they provide. In online spaces, this can be performed in many different forms, such as through text-based comments, posts, articles, or videos. Savolainen (2017) conceptualizes knowledge and information sharing in online environments as “give, provide, disseminate, transfer, and post” (p. 11).

URL links or hyperlinks go by different names in various studies and have been useful in observing data mining practices and understanding information flow on websites and social media (Vaughan, 2016). URL links are widely used to share information, acting as bridges between webpages or posts and allowing users to access and distribute knowledge across different domains (Sams and Park, 2014). These links function as external resources and are being used in comments to enhance the trustworthiness for one’s opinions, especially in scientific discourses (Dubovi and Tabak, 2020; Singh *et al.*, 2020). They can provide credibility, evoke curiosity, or trigger discourse in those who come across it (Go *et al.*, 2016; Sams and Park, 2014). In a way, it gives the opportunity for other users to simply click or copy and paste the link to find the originality of the source and make their own conclusions on the information provided. While previous studies have looked at the motivational factors of referencing scientific publications and how it changes discourse moves, not many have looked into the links themselves and how it aligns with the comment’s arguments (Nelon *et al.*, 2021; Striewski *et al.*, 2022).

#### *Previous anti-vaccination studies on social media commenting*

Among the different topics of scientific discourse, we focus our attention on the vaccine discourses on social media. Vaccination is a profound topic that has provoked discourses among experts and non-experts over diverse social media platforms ever since the misleading information of its connections to autism emerged in a research paper (Kolodziejcki, 2014). Thus, studies on the topic of vaccine discourse on diverse social media platforms have examined different aspects of commenting in relation to misinformation, argumentation tactics, and attitudes. Individuals use different strategies to convey their arguments – such as peripheral processing tactics to persuade through stories or perceived threat/fear appeal to induce negative emotions (Scannell *et al.*, 2021). Nguyen and Catalan-Matamoros (2022) examined how those with an anti-vaxxer stance were the most engaged in vaccine discourses on Twitter and discovered that anti-vaxxers used little scientific evidence and focused on personal opinions. On the other hand, some studies have shown the impacts of scientific research being used in vaccine-related comments. Publications of major scientific research can verify correct information which can reduce the comments of anti-vaxxers (Nelon *et al.*, 2021). Striewski *et al.* (2022) examined how individuals are more likely to cite scientific papers to challenge and provide stronger evidence for their arguments.

Oftentimes, anti-vaxxers in vaccine discourse are active commenters. Lu and Sun (2022) mention how anti-vaxxers are the most active commenters who argue for negative aspects of vaccines, which influence others on vaccine hesitancy. In some cases, people act like experts to sound credible and influence other comments (Gierth and Bromme, 2020).

In the case of attitudes and sources, Nguyen and Catalan-Matamoros (2022) found that most Twitter users did not provide a clear source to their anti-vaccination arguments and that the few arguments that indicated sources used less credible sources. However, not much has been investigated on the types of evidence individuals use to claim credibility and validity of their

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argument. Previous research has pointed out how anti-vaxxers are prone to ignore scientific evidence and health experts (Davis, 2019). Motta *et al.* (2018) explain this type of attitude in anti-vaxxers with the Dunning–ruger effect, which suggests that individuals who tend to become more overconfident are more likely to underestimate medical experts and rely on non-professionals when deciding their stances on vaccine policies. This can be closely examined with an individual’s choice on vaccines and their health literacy demonstrated on the internet through blogs, websites, or content-sharing platforms. Those who are overconfident are most likely to not probe further for more information beyond their comfort level regarding health-related information (Canady and Larzo, 2022). In our study, we consider these prior observations as we examine our own data and answer our research questions.

### *Connectivism and information literacy*

As mentioned earlier, we assert the importance of YouTube for its educational value and how the platform itself promotes knowledge sharing. Individuals tend to rely heavily on social networking sites as an initial source of advice, information, or news (Go *et al.*, 2016). In consideration of vaccine discourses and other health information, younger generations tend to seek and share information from the internet, rather than seeking or confirming it directly from the health or medical professionals (Basch *et al.*, 2018). In addition, despite being tech-savvy and highly competent in information-seeking behaviour, they still lack the skills in evaluating sources and are prone to accept and spread conspiracy theories and misinformation that circulate on the internet (Basch *et al.*, 2018; McGrew *et al.*, 2018). This calls for the need for information literacy. Information literacy is the ability to critically access and retrieve information in online spaces (Koltay, 2011; Leaning, 2019). This is crucial as misinformation and fake news have always been rampant on social media platforms, especially about vaccines during the spike of COVID-19 (Prada *et al.*, 2023). In the case of YouTube, Donzelli *et al.* (2018) mention how its algorithm also plays part with exposing users to negative videos on vaccines, which can affect a user’s viewpoint and receiving information.

In this light, it is important to understand how users are sharing information and knowledge with others within their online community and how they are identifying information being exchanged and posted (Burclaf and Johnson, 2016). This can be observed through the perspectives of the connectivism theory, which emphasizes an individual should be able to distinguish between important and unimportant information in the hub of resourceful networks (Siemens, 2005). YouTube aligns with this theory as a node that allows individuals to connect with other learners, while also extracting, exchanging, and evaluating information for their own purposes (Haugsbakken and Langseth, 2014). Previous studies have used connectivism to explore how individuals can use the features of YouTube to expand their learning and engagement outside of formal contexts (Greenhow and Lewin, 2016). Dunaway (2011) mentions how connectivism also closely matches with the goals of information literacy, being how both look at new learning practices in technological spaces. Thus, we discuss and apply connectivism more in our theoretical framework section.

### **Theoretical framework**

In consideration of how YouTube aids individuals to access information and connect with other users from diverse backgrounds to exchange knowledge, we used the theoretical framework of connectivism. Using the theory as an initial analytical lens, we focused on how an individual obtains, evaluates, and shares scientific information and argumentation within the YouTube platform. Introduced by Siemens (2005) and Downes (2019), connectivism looks at the actions and learning process of individuals equipped with online tools. Siemens (2005) mentions that “learning is a process of connecting specialized nodes or



information sources” and argues that the “ability to see connections between fields, ideas, and concepts is a core skill” (Connectivism, para 3). Digital technology has become an essential tool for learners in the 21st century. Individuals no longer gain information from a single source or node but learn and choose from multiple platforms that are available online, such as blogs, websites or social media (Shrivastava, 2018). Individuals are given an opportunity to expand and explore different types of knowledge and information presented through these multimodal modes (Conradie, 2014). Social media, like YouTube, is one of the platforms that allow connectivist learning to occur. Such platforms provide information and space for individuals to create and share knowledge that can also be distributed to other platforms at the same time (Goldie, 2016). With this in mind, we examine the comments section of YouTube, which functions as the hub of information and opinion exchange, to understand how individuals are capable of extracting and connecting information.

Commenting with URL links also plays a crucial role in facilitating connectivist learning by enabling individuals to expand the connection of diverse resources and providing the connection to other networks of nodes. As much as the focus of the connectivism theory is on the learner, it is important for individuals to be actively engaged in this environment and be equipped with the skills to make informed decisions. This will allow effective learning to occur in an online environment (Siemens, 2005). Knowledge and information are constantly generated and changing in the digital world, and connectivism is a useful theory to understand how individuals learn and demonstrate how skills like information literacy are needed more than ever (Dunaway, 2011). In this scenario, individuals need to know how to select what they need from an abundant pool of resources while comparing it with their already existing knowledge (Haugsbakken and Langseth, 2014). In other words, individuals need the ability to extract and connect different portions of acquired information together when making conclusions about certain topics. To observe this, we look at URL links and focus on what information sources are being shared and how the information is being used among individuals using the commenting feature. Therefore, this theory helps provide a foundational lens to understand how individuals are accessing and evaluating information and how they are connecting the different nodes of sources when replying to the videos on vaccines.

## Methods

### *Data*

Our study aimed to understand the knowledge-sharing methods behind vaccine discourses. We used content analysis and focused on examining the URL links users posted in their comments. Firstly, we collected data by gathering vaccine-related informative videos on YouTube. The videos were searched using keywords related to vaccines, such as “vaccines”, “anti-vaxxers”, and “debunking anti-vaxxers”. We focused on informative videos that deliver scientific information on how the vaccine works and discuss the risks of vaccination with an expert knowledge. Videos that only focused on entertainment purposes (such as talk shows or those that did not focus on conveying scientific information) were excluded from our search. We also looked at videos that either debunk/challenge or explain facts about vaccines and were created before the COVID-19 pandemic. To focus on videos that have a high interaction rate and active discussion, we chose videos with more than one million views and one thousand comments and which were published in a channel with more than one million subscribers. Finally, we factored in an individual’s short attention span and the likelihood of the commentors finishing the whole video (Geri *et al.*, 2017). Thus, we excluded videos that were longer than 15 minutes. As a result, eight information-based videos that fit our criteria during this stage were chosen (see Table 1).

**Table 1.**  
Summary of selected videos and extracted comments for data analysis

Year	Title	Channel name	Length	View count (as of May 2022)	In English	# Comments With URL (s)	Sampled
2015	The science of anti-vaccination	SciShow	9:15	2.9M	8,709	490	100
2015	How do vaccines work? – Kelwalin Dhanasarnsombut	Ted-Ed	4:35	2.6M	1,139	88	51
2015	How risky are vaccines?	MinuteEarth	3:26	1.3M	1,961	55	42
2015	Why vaccines work	BeSmart	7:22	1.0M	1,416	84	70
2015	Why are there dangerous ingredients in vaccines?	MinuteEarth	2:47	1.3M	1,170	29	21
2017	The thing about vaccines . . .   vaccine controversies   doctor mike	Doctor Mike	6:37	1.3M	5,246	257	100
2018	Debunking anti-vaxxers	asapSCIENCE	7:23	6.0M	25,817	1,684	100
2019	Doctor reacts to middle ground: pro-vaccine vs anti-vaccine	Doctor Mike	14:35	7.4M	25,736	334	100

**Source:** Table by authors



We developed a Python script to retrieve English comments containing URL links from each video. Firstly, we used the YouTube API (<https://developers.google.com/youtube/v3>) to extract all comments from each video, subsequently using the LangDetect (<https://pypi.org/project/langdetect/>) module to filter out non-English comments. Following this, we used the UrlDetect (<https://pypi.org/project/urlextract/>) module to identify and retain comments containing URLs. As a result, a total of 2,766 comments with URL links were collected from all videos. Within the pool of 2,766 comments, we manually removed comments that were irrelevant to the topic of vaccines (e.g. advertisements, clickbait, suggestions to join social media groups, or petitions). For videos that had over 100 relevant comments (four out of eight videos had over 100 relevant comments each), we randomly sampled 100 comments from each video. This sampling was done to ensure a balanced representation of comments across videos and considering the challenge of manually coding a large number of comments. As a result, a total of 584 comments were used for the final analysis.

### *Stances on the vaccination*

Sampled comments were analysed by their stances on the vaccination and by the types of cited sources. As shown in [Table 2](#), the stances on the vaccination were categorized into four types: pro, anti, neutral, and unclear. The total number of stances from all eight videos are shown in [Table 3](#). Two researchers coded 120 comments from one video together to build consistency between the coders. Then, the two coders coded 360 comments independently, compared the result and discussed to reach an agreement. The inter-coder agreement was 0.89 (Cohen’s Kappa). One researcher coded the stances for the remaining comments, and the other researcher reviewed the result.

### *Type of information sources*

To answer our first research question on the types of information sources, we categorized the referenced links by their source type, as shown in [Table 3](#).

Code	Description	Example comment
Pro	Comments that express pro-vaccination. If only links exist, the source itself promotes pro-vaccine	“Since 2011, A link is believed to be between Autism and ESTROGEN!! It’s been found between the mother and the fetus . . . in the womb. NOT vaccines!! <a href="http://www.sciencedaily.com/releases/2019/07/190729094538.htm">www.sciencedaily.com/releases/2019/07/190729094538.htm</a> . . .”
Anti	Comments that express anti-vaccination. If only links exist, source itself promotes anti-vaccine.	“. . . Also keep in mind that Autism is only one of the multiple shown consequences of vaccine administration, as they have been linked to a number of other ailments. ⇆ <a href="http://www.activistpost.com/2013/09/22-medical-studies-that-show-vaccines.html">www.activistpost.com/2013/09/22-medical-studies-that-show-vaccines.html</a> ”
Neutral	Does not indicate stance in context or comment	“Dr Mike, I have a question, what’s your opinion on this article.. <a href="https://youtu.be/JR8gw6GLwug">https://youtu.be/JR8gw6GLwug</a> Skip @23:10”
Unclear	Only commented a single/multiple link(s) without context and cannot identify content with one of the above categories	“ <a href="http://www.youtube.com/watch?v=LEWPBhDDu1I">www.youtube.com/watch?v=LEWPBhDDu1I</a> ”

**Source:** Table by authors

**Table 2.**  
Codebook for stance  
on the vaccination

**Table 3.**  
Codebook for the  
type of cited sources

Category	Subcategory	Description	Example comment
Home address of website	Government, university or research centre	Links that direct to the homepage of a government/university/research centre website, and not to a specific article, page or section	"... The truth is, based on information from hrsa.gov, for every 1 million doses of vaccine that were distributed, approximately 1 individual was compensated..."
Video	Antivax/Pseudoscience	Links that direct to the homepage of an anti-vax/pseudoscience website, and not to a specific article, page or section	"... I follow the work of Dr Michael Greger (nutritionfacts.org) and Dr Neil Barnard (PCRM) who spend time going over peer reviewed science and presenting the information that we need to see..."
	Informative video or documentary	Videos that focus on delivering information, rather than relying on the impact of the individual conveying it	"... The problem is that vaccines have never been properly safety studied, so no one knows the true harm. Here's a 5 min overview including recent data from a CDC FOIA request and other good info: <a href="http://www.youtube.com/watch?v=G_YSKVfVYUQ">www.youtube.com/watch?v=G_YSKVfVYUQ</a> "
Document/report	Influencer video, news clips	Videos involving individual people, influencers in society, news clips, talk shows (that have influencers), [...].etc.	"Please listen very carefully to what Bill Gates has to say in this TED talk <a href="https://youtu.be/jaF-fq2zn7lP4">https://youtu.be/jaF-fq2zn7lP4</a> = 201, especially the 1st part..."
	Government, university or research centre	PDF or word documents that are not necessarily "research papers" and related to science-based websites	"... Also, here is the CDC Website that does not go into as much detail, but lines up with the other link by Procon. → <a href="http://www.cdc.gov/vaccines/pubs/pinkbook/downloads/appendices/B/excipient-table-2.pdf">www.cdc.gov/vaccines/pubs/pinkbook/downloads/appendices/B/excipient-table-2.pdf</a> "
Research paper	Anti-vax/pseudoscience	PDF or word documents that show anti-vaccination stances	"Here are 130 studies with links to neurological disorders. <a href="https://go.thetruthaboutvaccines.com/wp-content/uploads/130-STUDIES-LINKING-VACCINES-TO-NEUROLOGICAL-AND-AUTOIMMUNE-ISSUES-COMMON-TO-AUTISM.pdf">https://go.thetruthaboutvaccines.com/wp-content/uploads/130-STUDIES-LINKING-VACCINES-TO-NEUROLOGICAL-AND-AUTOIMMUNE-ISSUES-COMMON-TO-AUTISM.pdf</a> "
	Government, university, research centre or mainstream media	Peer-reviewed empirical papers posted on publishing websites or in PDF format	"Can anyone help explain this, got it someone that is anti-vaccine ... my brain is starting to hurt, thanks! <a href="http://jid.oxfordjournals.org/content/197/7/950.long">http://jid.oxfordjournals.org/content/197/7/950.long</a> "
Article	Government, university, research centre or mainstream media	Articles in text-based format (blog writing, news article, [...].etc.) that are from government, university, research centre or mainstream media	"For all those who think measles is not dangerous and vaccines are 'worse', I urge you to view this <a href="https://metro.co.uk/2018/06/14/mum-shares-devastating-pictures-daughters-slow-death-measles-7632488/amp?itio=amp-more-item-1">https://metro.co.uk/2018/06/14/mum-shares-devastating-pictures-daughters-slow-death-measles-7632488/amp?itio=amp-more-item-1</a> "

(continued)

Category	Subcategory	Description	Example comment
Not available	Anti-vax/pseudoscience	Article formats that are from websites that express anti-vaccination stances or conspiracy theories Links that have been removed, 404 error pages, pages removed for violation	“Italian Court rule Vaccines cause AUTISM <a href="http://healthimpactnews.com/2015/u-s-media-blackout-italian-courts-rule-vaccines-cause-autism/">http://healthimpactnews.com/2015/u-s-media-blackout-italian-courts-rule-vaccines-cause-autism/</a> ” <a href="http://www.youtube.com/watch?v=QsZbVg6vmVs">www.youtube.com/watch?v=QsZbVg6vmVs</a>
Other		Sources that do not fit the above six categories (books, graphics, pictures, podcasts, . . .etc.)	“ . . . here’s vaccines for dummies: <a href="https://medium.com/the-nlb/vaccines-work-here-are-the-facts-5de3d0f9ffd0">https://medium.com/the-nlb/vaccines-work-here-are-the-facts-5de3d0f9ffd0</a> (Both of those videos’ ‘points’ are addressed in this little comic)”

**Source:** Table by authors

Exploratory  
study of  
YouTube  
comments

**Table 3.**

The researchers went over the comments from the first video and noticed several recurring categories that emerged during the initial coding process. The final set of categories was established through internal iterations. With the established set of categories, the first coder analysed 584 comments, and the second reviewed the coded result. In cases where comments cited multiple links, we grouped each type of source together and counted them as one. For example, if a single comment contained three different URL links to research papers and five different URL links to influencer videos, they were just grouped together and marked as a single occurrence for each respective category, rather than separately counting the number of occurrences. We made this decision since our aim was not to count each number of links but to understand how often they are used to support one’s argument.

For specific source types such as websites, documents/reports and articles, we conducted supplementary assessments of credibility. Here, we define “credibility” as the trustworthiness/purpose, originality, and expertise of the source (Rains and Karmikel, 2009). The website Media Bias/Fact Check ([mediabiasfactcheck.com](http://mediabiasfactcheck.com)) was used as an aid to determine the credibility of the websites.

*How information in URL links is shared and used*

We investigated how information in the cited sources is shared and interpreted in comments by analysing and comparing the content of the original sources and comments. We manually went through the comments and looked if individuals demonstrated any information literacy abilities in “selecting, locating, and using appropriate information sources; pulling the information together” from the sources they included in their comments (Eisenberg, 2008, p. 42). In other words, we examined what pieces of information YouTube users were extracting from the original sources and compared it to what they had mentioned in their comments.

For comments citing research papers, we used the URL links to access the original article, and then we read each cited paper and searched for the excerpts that were used to support their statement. We then examined the excerpts to see if it was matched the argument of the paper or if there is any discrepancy or incorrect interpretation. For example, if a comment contained a quote about how many vaccines caused deaths in recent years but the original paper advocated for additional research to enhance vaccine safety, we classified these comments as misleading.

**Findings**

Out of 584 comments analysed, 75 were pro-vaxx, 397 were anti-vax, 54 were with neutral stance and the stance of 58 comments was unclear, as detailed in Table 4. Although the number of pro-vaxxer comments was relatively higher when randomly sampled (out of randomly sampled 300 comments, 178 were pro, 65 were anti, 25 were neutral and 32 were unclear or irrelevant), the majority of the comments using URL links to validate their arguments were from anti-vaxxers (397 comments out of 584).

**Table 4.**  
Number of comments sampled by stance on vaccines

Category	Stance			
	Pro	Anti	Neutral	Unclear
Total	75	397	54	58

**Source:** Table by authors

To answer our first research question:

*RQ1.* Which type of information sources did YouTube users rely on when providing evidence for their arguments on vaccination?

We first present the types of cited sources in URL links that are used as evidence to back up opinions. Then, in response to our second research question:

*RQ2.* How are users sharing and using URL links to support their claims and arguments in their YouTube comments.

We present qualitative findings on how information in URL contents were used in those comments.

*RQ1. Which type of information sources did YouTube users rely on when providing evidence for their arguments on vaccination?*

The number of comments citing each type of resource, organized by stance, is summarized in [Table 5](#). For pro-vaxxer comments, categories that appeared the most were *Informative video and documentary* (33.3%), *Articles from credible websites* (21.3%) and *Research papers* (10.7%). Categories that stood out the most among the anti-vaxxers comments were: *Not available* (36.3%), *Article on less credible websites* (20.2%), *Research papers* (14.4%) and then *Videos of influencer* (12.8%). The most cited type of source by neutral stance comments were *Not available* (29.6%), *Research papers* (25.9%) and *Articles from credible websites* (16.7%). For the comments coded as *Unclear*, 54 of the 58 comments had URL links to YouTube videos, which were deleted for violating community guidelines and from webpages with pages that were no longer available.

Our quantitative results showed an interesting number of highly used sources for each stance. For the pro-vaxxers, *Informative video and documentary* (33.3%) was the highest types of sources used to cite their sources. When each link was examined, many of them were from other informative or education-based videos on YouTube explaining the history or effectiveness of vaccines. Some were videos made by content creators, while some were excerpts from documentaries or interviews of influential people.

#### *Research papers cited in vaccine discourses*

In our codebook, we defined the category *Research papers* as peer-reviewed empirical papers that are either posted on peer-reviewed journal publishing websites or uploaded as a PDF file with an indication of the published journal. Although research papers are primarily written for professionals and scholars in the field and not for general public communication, our findings indicate that the public still perceives them as credible sources of evidence on scientific topics. Many individuals used the sources to argue information presented in the video. This was shown through the links of papers that studied different vaccine topics published in various publication venues.

Despite the common belief that anti-vaxxers focus on narrative and episodic stories rather than scientific or factual information, the proportion of anti-vaxxer comments citing research papers was similar to that of pro-vaxxer comments ([Nguyen and Catalan-Matamoros, 2022](#)). The following comment shows an example from an anti-vaxxer using a link from the National Library of Medicine (NLM):

It's interesting though, because. . . "Linear regression analysis of unweighted mean IMRs showed a high statistically significant correlation between increasing number of vaccine doses and

**Table 5.**  
Number of comments  
cited each type of  
Webpage by stance  
on vaccines

Category	Stance			
	Pro	Anti	Neutral	Unclear
Total number of cited sources	75	453	57	59
<i>Home address of website</i>				
Government, university or research centre	1 (1.3%)	5 (1.3%)	0 (0.0%)	0 (0.0%)
Anti-vax/Pseudoscience	1 (1.3%)	17 (4.3%)	2 (3.7%)	1 (1.7%)
<i>Video</i>				
Informative video or documentary	25 (33.3%)	12 (3.0%)	5 (9.3%)	0 (0.0%)
Influencer video, talk shows	7 (9.3%)	51 (12.8%)	4 (7.4%)	0 (0.0%)
<i>Document/report</i>				
Government, university or research centre	0 (0.0%)	8 (2.0%)	1 (1.9%)	1 (1.9%)
Anti-vax/pseudoscience	0 (0.0%)	12 (3.0%)	1 (1.9%)	0 (0.0%)
<i>Research paper</i>				
Article	8 (10.7%)	57 (14.4%)	14 (25.9%)	0 (0.0%)
Government, university, research centre or mainstream media	16 (21.3%)	41 (10.3%)	9 (16.7%)	0 (0.0%)
Anti-vax/pseudoscience	7 (9.3%)	80 (20.2%)	3 (5.6%)	1 (1.9%)
Not available	7 (9.3%)	144 (36.3%)	16 (29.6%)	54 (93.1%)
Other	3 (4.0%)	26 (6.5%)	2 (3.7%)	2 (3.4%)

**Source:** Table by authors



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increasing infant mortality rates, with  $r = 0.992$  ( $p = 0.0009$ ) [www.ncbi.nlm.nih.gov/pmc/articles/PMC3170075/](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3170075/). How's that ^ for evidence? (Comment 582)

Exploratory  
study of  
YouTube  
comments

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Most of the articles from anti-vaxxers were found from the NLM (36 comments out of 57 using them as sources), and a handful of the publications were from SpringerLink, ScienceDirect and Oxford Academic. Examples of peer-reviewed journal articles include *The New England Journal of Medicine (NEJM)*, *American Journal of Public Health (AJPH)*, *EBioMedicine* and *Proceedings of the National Academy of Sciences (PNAS)*. The articles from pro-vaxx and those of neutral stance were more diverse in sources.

*RQ2. How are users sharing and using URL links to support their claims and arguments in their YouTube comments*

Through observing arguments and types of sources from all three stances, many of the comments were mostly made in the form of simple quotes, questionings, and sometimes mockery. These were mostly formatted as a response to the video content, such as pointing out, questioning, or disagreeing with a fact that was mentioned. Many of the quotes did not include personal opinions and focused on the links they were citing. Some were in the form of full sentences through direct copy and paste, with little opinion or details of the original sources mentioned. Some of them were in the form of a single sentence to explain their source, and some of them were in full paragraphs of three or more sentences, which gave more information about the context. In other comments, some users combined quotes from passages and personal opinions by using one or two URL links as a citation for their source. These were added mostly at the end of their statement. The following excerpt from an extremely long comment demonstrates this:

[. . .] I just have a hard time having compassion for someone who is willingly putting their child in danger and especially when they cross the line and advocate for other parents to do the same not understanding the harm they are causing. Look at the 1988-90 outbreak in California. 75 lives, more than half of which were under 5 years of age. All completely preventable. [www.ncbi.nlm.nih.gov/pmc/articles/PMC1022280/](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC1022280/) (Comment 8053)

Several users provided multiple URL links by simply copying and pasting them as a list in their comments. They would go from five links to a list of 23 links. Some comments only included research papers as their source. Other comments combined different types of sources, such as links to news reports, video clips from other video-based social media platforms, or government websites. Again, some of the users included meta-information such as the title or an excerpt in addition to the article itself, but many others simply copied and pasted the links without further explanation. This brings into question whether the individuals went through each link themselves to verify the contents or get more information. This was observed mostly among anti-vaxxers. Pro-vaxxers and those of neutral stance did not present a long list of URL findings. Their number of links was mostly one to three. The following excerpt is an example of a user who mentioned multiple research articles in their comment:

If there is no evidence vaccines are dangerous or cause autism why does all this information exist? Why have I found over 500 additional published studies documenting the dangers of vaccines and their adjuvants? [www.ncbi.nlm.nih.gov/pmc/articles/PMC3878266/](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3878266/)

[www.ncbi.nlm.nih.gov/pubmed/21623535](http://www.ncbi.nlm.nih.gov/pubmed/21623535)

[www.ncbi.nlm.nih.gov/pubmed/25377033](http://www.ncbi.nlm.nih.gov/pubmed/25377033). . . (Comment 938)

On the other hand, in comparison to pro and anti-vaxxers who used links to respond to the video content, those of a neutral stance used links to question or express their thoughts and

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concerns about their cited sources. This was shown in 10 out of the 15 comments, and the comments formed as a question, concern or request for confirmation regarding their URL links. Some comments gave more explanation about the cited source, and some comments expressed encouragement for others to read the links. An example comment shows how the user showed confusion and requested clarification about their sources:

[...] From what I've read, it seems that the theory itself was based on an observation of natural immunity, not vaccine induced immunity, which is less effective and long lasting compared to natural immunity. Hence, herd immunity is unachievable through vaccines. If I'm wrong about this, and herd immunity does in fact apply to vaccines, then how would this be possible? [www.ncbi.nlm.nih.gov/pubmed/8483623](http://www.ncbi.nlm.nih.gov/pubmed/8483623) [wwwnc.cdc.gov/eid/article/6/5/00-0512\\_article](http://wwwnc.cdc.gov/eid/article/6/5/00-0512_article)

<https://academic.oup.com/aje/article-abstract/139/1/77/211503>... (Comment 10)

Through the analysis, we observed that many users consider posting links as a method of providing evidence-based arguments. However, many of these comments did not show a higher level of understanding or reasoning. Most of the time, links were simply presented in the form of copy and paste with the indication of commenters' stance towards vaccines.

#### *Inaccurate information usage of research papers*

As mentioned in the beginning section of our findings, based on the high number of anti-vaxx comments using URL links, there was a high use of research papers as evidence. In total, the amount surpassed those of pro and neutral stance on vaccines. For example, one user used a research paper to refute information about herd immunity mentioned by one of the informative videos:

I guess you haven't paid attention to the current flu issue. [www.pnas.org/content/early/2018/01/17/1716561115](http://www.pnas.org/content/early/2018/01/17/1716561115) People who receive flu shots emit 630% more virus particles into the air compared to non vaccinated. In other words the vaccinated become a herd of spreaders. (Comment 470)

However, while many comments have been able to cite various sources to validate their arguments, many did not seem to understand or deeply evaluate the information they had acquired. For example, in one comment, we noticed how it was composed of research paper titles with a negative tone towards vaccines. The paper itself in general mentions what instances caused outbreaks in the community and also mentions the importance of a two-dose MMR vaccine. Although the user claims the article is a proof of why vaccination is useless, the paper by [Barskey et al. \(2012\)](#) itself mentions "The features of this outbreak are best explained by intense exposures, particularly among boys in schools, that overwhelmed the protection afforded by the vaccine (p. 1710)" and that the fact that the outbreak did not spread to surrounding communities highlights the effectiveness of the two-dose MMR vaccine schedule in most settings (p. 1711):

THE VACCINATED GET MUMPS: [...] 2012 Re 2009-2010: Mumps Outbreak in Orthodox Jewish Communities in the United States (Highly vaccinated at that time -makes you wonder why they are not vaccinating now) [www.nejm.org/doi/full/10.1056/NEJMoa1202865](http://www.nejm.org/doi/full/10.1056/NEJMoa1202865) [...] (Comment 303)

This inaccuracy was noticed in several other comments. For instance, some quotes were taken out of context from the articles. Some articles were not focused on the disapproval of vaccines, yet the comments displayed excerpts from the vaccine research that showed a negative tone or facts. In the excerpt below, the user argues how the paper shows a positive correlation between deaths and vaccine doses. However, the article itself does not focus on the harmful aspects of vaccines; but rather, it explains why their results are useful for administering safer vaccine schedules:

Our findings show a positive correlation between the number of vaccine doses administered and the percentage of hospitalizations and deaths. [www.ncbi.nlm.nih.gov/pmc/articles/PMC3547435/](http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3547435/) Those dangerous chemicals are in there to kill you. This dumb YouTube clip says it to help you. Lol dumb millennial retards. (Comment 967)

Similarly, while some used different sources to back up their statements, others simply did not seem to check the originality of their sources. One user mentioned:

WHO is World Health Organisation. Just google WHO sterilises women in third world. You will see many articles in reputable news sources reporting on the WHO knowingly sterilising women in the third world through vaccines without their knowledge or consent [...]. [www.snopes.com/medical/disease/tetanus.asp](http://www.snopes.com/medical/disease/tetanus.asp) [...] (Comment 2929)

From this comment, we found that the user only used the title of the article to validate their argument. Snopes is a fact-checking website, and if the user scrolls down, one can read “false claim” at the bottom. Thus, compared to the above findings of showing strong information seeking in scientific resources, it was seen that individuals, especially anti-vaxxers, did not extract information that portrayed the intended purpose of the papers but rather use only portions that were useful for their stance on vaccines.

## Discussion

Our analyses show that individuals are active in knowledge sharing and are efficient in seeking diverse online information sources. However, our analysis of comments showed how they are likely to extract information from original sources based on their beliefs or to use them for their own advancement of scientific reasoning. These arguments may look credible with the verifiable URL links to the original source. Nonetheless, this can be misleading and can provide false clarification for others in scientific discourses. Therefore, critical thinking and source validation is needed when acknowledging these characteristics of social media comments, as information may be taken out of context. YouTube is also considered as a useful educational tool to implement in different learning environments (Maziriri *et al.*, 2020). YouTube itself functions as a useful platform that fosters discourse and knowledge-seeking practices, but careful consideration is needed when accessing information in the comments section.

### *YouTube as a platform to foster discourse and knowledge sharing*

By observing comments and how YouTube users use external resources, we found how science-based videos on YouTube can bring out strong discourse motivations and information sharing attitudes in the comment section. This is consistent with other studies that have looked at how social media platforms host content and discourses addressing scientific or health topics (Davis, 2019; Nelon *et al.*, 2021; Striewski *et al.*, 2022). Dubovi and Tabak (2020) also mentioned that users were apt to engage highly in commenting when challenged with contradicting knowledge or those by other commenters. In our case, this was the scientific controversy over vaccines. Regardless of the stance on vaccines, many of the comments challenged, contradicted, or questioned certain information presented in the videos. For example, if a video declared that there is no direct impact of vaccines on autism, individuals would bring up vaccine-related research papers that mention autism. Another study showed how individuals on Twitter tweeting about COVID-19 information were prone to use information mostly from other social media platforms and news media for their URL links (Singh *et al.*, 2020). In our study, we found how users cited scientific or public sources such as research papers and official documents. YouTube users used practices like defending one’s claims and questioning the arguments in the videos, which are some

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discourse characteristics of scientific argumentation (Berland and Reiser, 2011). This suggests that the quality of content (in our case, informative videos created by well-known science YouTube channels) may impact the quality of knowledge-sharing activities and argumentation among users.

In addition, 36.3% of the sampled anti-vaxxer comments used YouTube URL links that were either “not available” or “removed for violation”. While it is difficult to confirm the content of the videos, the number of comments citing YouTube supports the argument that many individuals are turning and relying on the platform itself to find information (Pires *et al.*, 2021).

#### *Information literacy skills and scientific discourse skills using external resources*

Our findings show how individual users on social media platforms are using diverse sources for their purposes. Not only were individuals looking for information on different websites but also in different formats, such as video clips, comic strips, or social media posts. This shows how individuals can actively forage information online from different sources, which are skills needed for information literacy (Koltay, 2011). Additionally, this shows how social media platforms like YouTube can be an abundant learning ground or a node for information/media literacy (Siemens, 2005).

Also, many of the URL links associated with research papers were used for direct quotes, titles, or only the link itself. Similar to the study of Gierth and Bromme (2020), little information was retrieved through the comments themselves. This was consistent among the anti, pro, and neutral stances on vaccines. For example, some mentioned “here” and added multiple links in their comments without further explanation of what the contents were. While they used links as “proof”, it was not clear if they had thoroughly read the source themselves. In the case of scientific reasoning and persuasion, these methods can be ineffective as individuals are less likely to find sources as credible when they do not have any understanding of the source (Gierth and Bromme, 2020). Others would directly copy and paste information. A few comments showed highly constructed opinions that included personal arguments and quotes from the source. This suggests a lack of evaluation in their own sources and low scientific reasoning in information literacy skills and raises a concern about the quality of knowledge sharing (Koltay, 2011; van Aalst, 2009).

Additionally, when previous papers have looked at each of the opposing sides of vaccine discourses (Canady and Larzo, 2022; Lu and Sun, 2022), it is worth observing the neutral stance comments on vaccines. The commentators with the neutral stance were more sincere about the links they provided and showed willingness to engage with the scientific evidence. According to Berland and Reiser (2011), this can be a process of sensemaking and knowledge construction in discourse. Most of the comments made by pro-vaxxers were similar to anti-vaxxers’ comments in that the commentators would quote or simply provide only the link as backups for their arguments. This is something to consider in information literacy practices and in constructing higher scientific reasoning in discourses (Berland and Reiser, 2011).

#### *Inaccurate information among users*

In the case of many anti-vaxxers who seemed to exhibit strong information seeking and sharing behaviours through the implementation of URL links, many were not able to demonstrate strong information literacy skills in critically evaluating, analysing, or citing the information they found (Koltay, 2011). Users were actively conveying their stances on vaccines through the use of external sources, but oftentimes, the sources were inappropriately cited or misused for their intention. When we probed deeper into the quotes

or links provided by anti-vaxxers, some were unrelated to the topic or did not match up to their arguments (9 out of 57).

Most of the research papers were either cited with direct quotes or with just the title of the papers. Upon further investigation, we found these quotes with a negative tone to vaccines were taken out of context and did not fully represent the purpose and content of the research paper. Many did not accurately convey the information in the original source. This raises the question whether individuals are using the credibility of research papers to their own advantage and underestimating the ability of others to validate the original source or speculating that others will take it for granted based on source reputation, rather than looking at the essential message of the source (Nelton *et al.*, 2021). This is similar to the findings of Davis (2019), who found that conspiracy websites tend to do the same thing by including scientific papers of little relation to use them as evidence and make misstatements about the purpose of the paper.

However, it is not to say that none of the papers mentioned were unrelated or misinterpreted by anti-vaxxers. There were some users who indicated research papers studying the relation of autism, infant mortality rates, or immunity reactions in connection to vaccination and included their opinions on why they think vaccines should not be implemented (20 out of 57). Some used inductive reasoning skills to argue why vaccines were harmful and, therefore, should not be forced on individuals. Contrary to previous research suggesting that individual anti-vaxxers are likely to deny information from experts and use less science-based evidence, it appears that they are using science-proven research papers and science-related influencers on video sharing platforms to back up their claims when compared to pro-vaxxers and those with a neutral stance (Motta *et al.*, 2018; Nguyen and Catalan-Matamoros, 2022). Many of the anti-vaxxer comments referred to sources from reputational science-based websites, suggesting their search practices are not limited to conspiracy websites. However, these links were provided in comments with little or without details of the content. In some cases, several of the links were repeatedly used across different comments in the same manner. These characteristics of copying and pasting information questions how these sources are being retrieved and shared in online spaces. This can become a concern considering the impact on individuals with low health literacy skills and how it can potentially help with the spread of misinformation (Canady and Larzo, 2022). Also, it appears that individuals, especially anti-vaxxers, are using these sources as a validation in response to the informative videos that refer to research papers and scientific evidence in their content. Therefore, to address these discrepancies in information sharing, we suggest the need to raise awareness in the critical thinking skills of individuals when accessing and engaging in scientific discourse. More information is discussed in the Implications section.

#### *Public understanding of science research papers*

The analysis of the sources gives new insights into our research questions, which look at the type of information sources and how they are used in scientific arguments. It is interesting to note how individuals often “misunderstand” the overall purpose of scientific research papers. This is not new, as it is known that non-expert individuals are likely to pick out information of their prior understanding, background, and experience (Motta *et al.*, 2018). This observation raises the question of “what is the public understanding of research papers? Are they generalizing what they read? Do they understand the purpose of scientific research papers?” Many anti-vaxxers used peer-reviewed papers as an ultimate conclusion to why vaccines are “bad” and why they should not be forced on individuals. However, this belief is contrary to the purpose of research papers themselves, as they are not conducted to

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define the absolute “right” and “wrong” in medication and that the research results cannot always be generalized. Part of this misunderstanding can arise from the public’s lack of awareness regarding scientific uncertainty. It is important for the public to acknowledge that scientific research is inherently uncertain, and each scientific finding rather offers interpretations of specific circumstances and observations. Regarding vaccine research, [Kampourakis and McCain \(2019\)](#) note that the public should trust the consensus and majority opinion among scientists, not a single research paper.

Furthermore, the act of cherry-picking information can potentially be dangerous as it can be a vehicle for spreading misinformation or disinformation. This can also be harmful for those with low health literacy skills or those who cannot access scientific sources. However, communicating scientific uncertainty with the public is challenging due to a prevalent aversion to scientific uncertainty ([Norris et al., 2003](#)). We suggest overcoming this challenge involves cultivating scientific literacy and promoting a nuanced understanding of scientific research within a broader context.

### Implications

Scientific information is accessible to the public and can potentially have dangerous outcomes when individuals with personal gains project it towards an audience with little preparation to critically interpret it ([Kolodziejski, 2014](#)). Although our study did not identify comments with malicious intentions of spreading disinformation, on many occasions, information was taken out of context and then communicated through the use of quotes which make it sound credible. The methods used to communicate their findings also lacked elaboration of the original content. While the consequences of these comments may look minimal based on the little information they convey, it is important to consider how these practices are still apt to spread misinformation through popular disputed topics like vaccines and can affect discourse quality in online spaces ([Nelson et al., 2021](#)). This is especially crucial today, considering that many young users are using YouTube for educational and information-seeking purposes as an alternative to Google in their daily lives ([Pires et al., 2021](#)).

Hence, our findings also provide educational implications. Informal learning is an extension from formal learning, and this requires educational researchers and literacy educators to pay more attention to how internet users today find, evaluate, and share their information outside of classrooms ([Asselin et al., 2011](#)). Individuals need to be more aware of the types of websites and how they portray their information to become responsible digital citizens. [Kivunja \(2014\)](#) states that educational paradigm shifts in helping students conduct problem-solving and critical thinking outside of school environments need to be emphasized in the 21st century. [Spikes and Rapp \(2022\)](#) propose educators to consider real world contexts to help students become more aware of misinformation/disinformation and practice how to effectively navigate in online spaces.

In addition, commenting on online platforms like YouTube can bring educational values in a way that allows individuals to exchange, transfer, and heighten information processing skills, not only to share knowledge but also to extend it to knowledge construction and creation as discourse practices in informal learning environments ([van Aalst, 2009](#)). Although we found that not everyone gives accurate information online or are providing detailed information for others about their cited sources, we suggest that the use of comments is important and helpful for audiences to understand and comprehend the messages being presented in the video content. We suggest the role of formal learning environments to scaffold and to prepare individuals so that they can implement these practices during self-directed learning. According to [Conradie \(2014\)](#), with the increase in



technology usage in education, connectivism can be used as pedagogical approach to help guide and allow online and personal learning environments to thrive. With the fast-paced change in knowledge distribution and technology, intervention methods may need to be reconsidered to teach upcoming generations about information literacy and knowledge sharing practices (Metzger *et al.*, 2015). During our data collection, we observed that many educational videos had their comments section disabled, which reduces the interaction of the viewers. We suggest enabling them can potentially enhance detecting misinformation and fake news, as well as providing the practice for information sharing. It is understandable that the choice of disabling comments may be to protect the video from bots, advertisements, malicious comments, and inappropriate wordings that are potentially accessible to children. Our findings show that individuals can evoke constructive knowledge and involve themselves in debates based on the uploaded content. This can induce practices in critical thinking and enable users to look for misinformation in other types of uploaded online content, whether it be a podcast, news article, or social media post. YouTube, therefore, is an excellent platform for individual learners to implement these practices of connecting with others, sharing knowledge, and exercising information literacy (Haugsbakken and Langseth, 2014).

### **Limitations and future directions**

There are a few limitations in our study. Firstly, the anti-vaccination topic is only a small topic in the vast midst of scientific discourses which can make our findings less generalizable. Another limitation of this study is that the analysis was done on a limited selection of videos and sampled comments on a small scale. While advancements in natural language processing have enabled use of semantic analysis and classification based on large data sets, the complexities inherent in vaccine-related discussions present challenges. The complexity of the topic itself and the presence of conversational nuances, such as the comments containing sarcasm or irony (“Anti-vaxxers, watch this and say that vaccines are a bad thing”), make it difficult to directly apply conventional methods. Future work can improve by developing an analysis technique that can effectively account for these challenges and analysing large-scale data ensuring accuracy and representativeness.

For future studies, it will be important to examine deeper into how users evaluate or use their scientific sources on vaccine discourses in YouTube and explore what more is needed in educating information literacy skills in informal learning environments today. In that regard, interactions between original comments and their replies and how argumentation occurs in this scenario could potentially be explored. Also, it would be interesting to explore how the comments section is affected by the content and how it can create more engaging knowledge co-construction for learning purposes. Moreover, future studies can expand and focus on how individuals interact with other scientific domains of discourse, such as climate change and genetically modified organism food safety. The following research question can also be explored: where do individuals find and share information, especially when the sources of information are unlimited? Finally, we also propose further research focusing on the individual’s perspectives of using YouTube as an information source and what impact instructional methods in videos have in learning outcomes among individuals or groups.

### **Conclusion**

This study examined information consumption practices that happen through comments in social media. By using content analysis and the connectivism theory as a tool of approach, we specifically explored the use of URL links among comments from eight educational YouTube videos. By narrowing down our topic to vaccines in scientific discourse, we

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observed how individuals are capable of interacting online to share scientific knowledge but lack skills in scientific reasoning and extracting accurate information. As Siemens (2005) mentions, in a world where information is constantly being created, added, and changed, individuals need the ability to navigate and critically assess this resource for it to be appropriately circled towards other individuals. Among many different sources and search paths, it is important that they are able to verify the information and recognize the responsibility to convey it to others. Especially now that technology has advanced to the point of integrating artificial intelligence (AI) tools that are able to fabricate photos and videos, individuals need a way to critically evaluate the real from fake. Additionally, fabricated information can be picked up through social media spaces and re-created for personal content on TikTok, YouTube shorts, and Instagram reels. This can then be shared through other platforms and contribute to the fast spread of inaccurate information. Learning is no longer an independent process with the introduction of digital technology, and individuals need the skills to use the resources for their own understanding which can be done with the help of other learners while also effectively sharing it with others (Downes, 2019).

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### Further reading

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